

10 STEP WAY TO HCAL Pulse

1. Beam Crossing

Launch particles from the IP with time drawn from a Gaussian $\langle t \rangle = 0$, $\sigma(t) = ?$

2. Time of Flight

Propagate particles through B-field to the front face of the calorimeter $\sigma(t) = 0$

3. SHOWER PHYSICS - high energy part (90%)

GEANT shower mechanics, keeping track of every scintillator hit in terms of

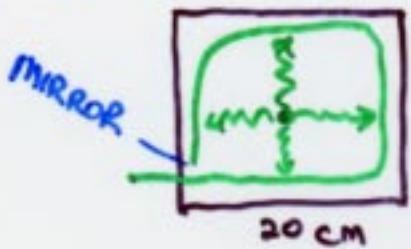
- geometry which scintillator
- time 2 nsec bins to start

Ignore the low energy neutron physics part (10%)

4. SCINTILLATOR LIGHT

Primary scintillation process gives 20,000 photons per cm per MIP. The decay time constant is 2.7 nsec. Simulation can subsume this step into the next two steps.

5. WAVE LENGTH SHIFTING FIBER LIGHT COLLECTION



Primary photons fill a length of WLS fiber ~ 80 cm long. Shifted and captured photons fill 80 cm + $80 \text{ cm} * \beta = 0.5$ due to mirror

Minimum pulse length = $1.6 \text{ m} @ \beta = .5 \Rightarrow \sim 10 \text{ nsec}$

Reflections inside the scintillator could no more than double this.

6. WLS Fiber Fluorescence

Re-emission of shifted photons via fluorescence follows $e^{-t/\tau}$ with $\tau = 12.5 \text{ nsec}$.

About 5% are captured in both directions.

Simulation can use a measured time-shape and yield function normalized to MIPs in the primary scintillator.

Pulse area is drawn from a Poisson distribution.

7. CLEAR FIBER TO PHOTODETECTOR Δt

Follow geometry of the hit scintillator to the photodetector using $\beta = 0.5c$.

This is a large η -effect but only a modest shower effect. Expect $\sim 5 \text{ nsec}$.

Clear fiber attenuation differences have been compensated by construction so that each scintillator should have the same yield at the photodetector $\pm ?\%$.

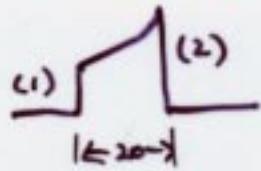
8. PHOTODETECTOR RESPONSE - efficiency

Quantum efficiency is 12%. ($\gamma \rightarrow pe$)

Throw the dice. (die?)

9. PHOTODETECTOR RESPONSE - time domain

Each photoelectron (pe) produces a 20 nsec wide Si-drift pulse shape in the HPD



Convolute the arrival time of each photoelectron with this response function.

10. PREAMPLIFIER RESPONSE - time domain

Convolution of the time-binned signal from steps 1-9 with the impulse response of the electronics.

Crucial to model accurately (May have 3-poles)

CDF PLUG

150 GeV h^+ HAD

Tek STOP Single Seq 2.00GS/s

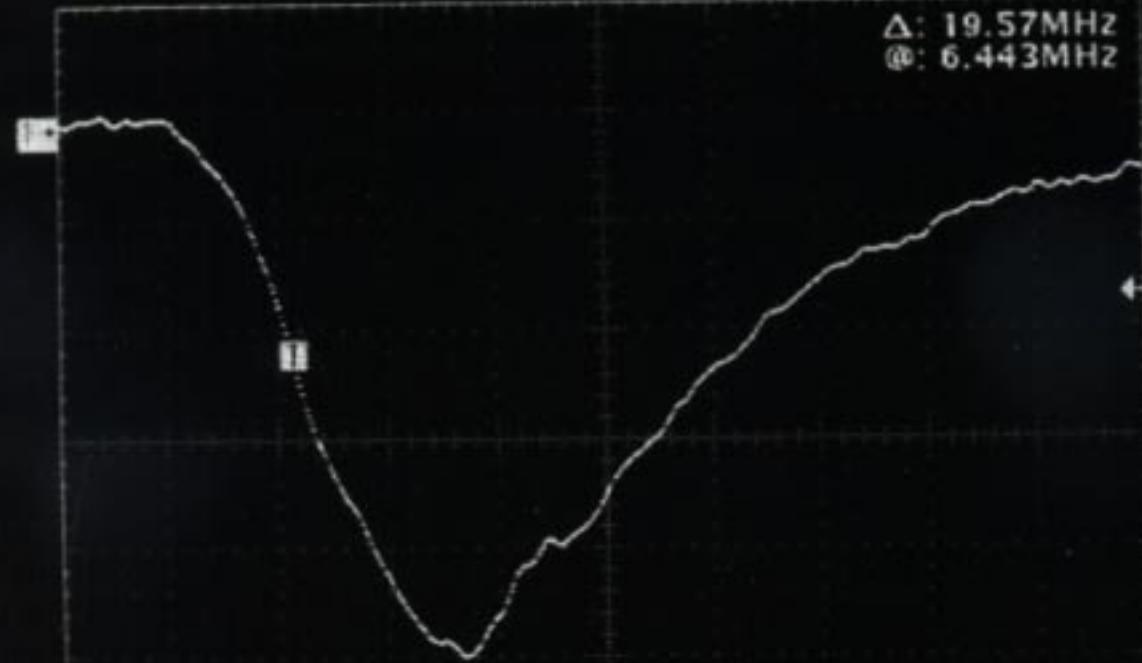
Main Scale: 5ns

$\Delta: 19.57\text{MHz}$
 $@: 6.443\text{MHz}$

Horizontal Scale

Main Scale
@ 50 Pts/Div
5ns

Delayed Scale
@ 50 Pts/Div
500ps



Ch1 50.0mV Ω Ch2 50.0mV Ω M 5.00ns Ch1 \wedge -78mV
Ch3 50.0mV Ω Ch4 50.0mV

Time Base Main	Trigger Position 20%	Record Length 2000	Horiz Scale (/div)	Horiz Pos	
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